Hydromechanical behaviour of water-repellent sands

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Introduction: *Extreme climatic events in the 21st century threaten the resilience of geotechnical engineering structures. Low-permeability barriers are at a particularly high risk of inundation under flooding or cracking during droughts, compromising the barriers and permitting contamination of the surrounding ground.*

Water repellent (WR) granular soils present an innovative solution to this problem. Hydrophobisation can arise naturally (e.g. due to deposition of organic matter, treatment with wastewater or wildfire), but can also be achieved in laboratory conditions by chemical treatment, typically with dimethyldichlorosilane (DMDCS).

Besides being resilient to volumetric change under changes in saturation, water repellent soils have been shown to slow down water and root penetration, thus making them a potential candidate for waste storage liners. However, the effect of water repellency on soil strength and permeability is not well understood.

Geotechnical challenges

- We must understand the hydromechanical behaviour of WR soils if we are to use them as part of geotechnical structures faced with varying degrees of saturation.
- Traditional unsaturated soils display wetting properties where all contact angles are <90^0; water menisci are concave and suction is positive (Figure 1a).
- Water repellent (WR) surfaces are defined as those with water-solid contact angles >90°. WR soils display convex menisci: water pressures in such structures must be **positive** (Figure 1b). This phenomenon has yet to be demonstrated in a laboratory setting.

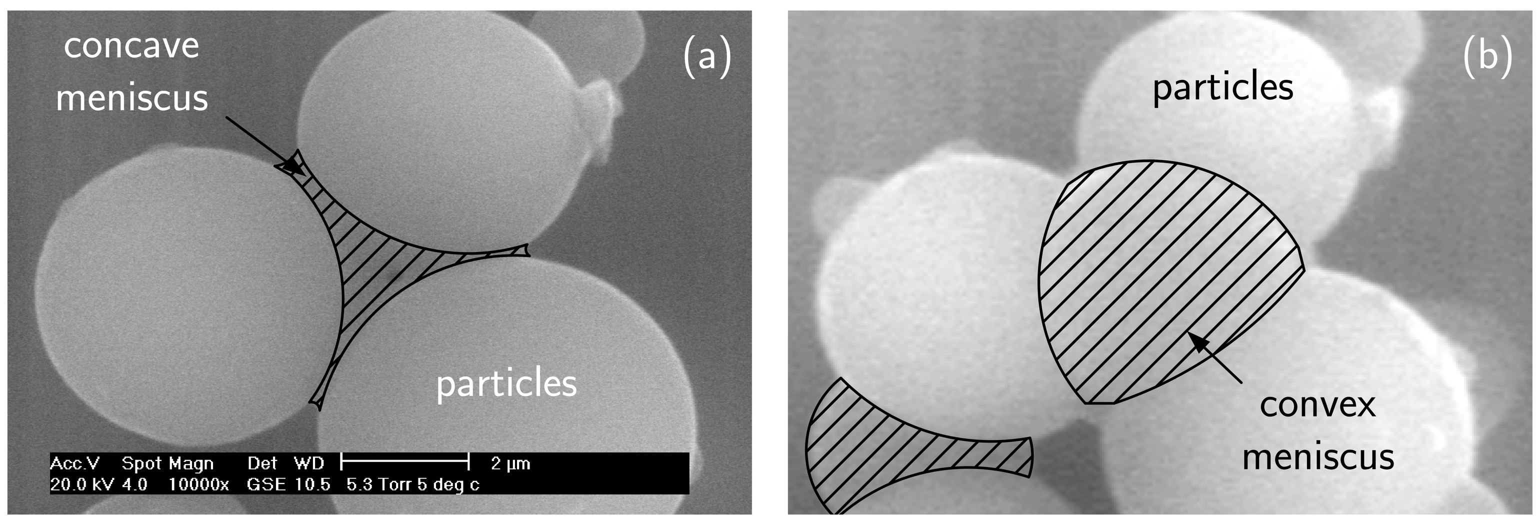

Figure 1. Water menisci between silica spheres a) hydrophilic; b) water repellent

Preliminary studies

- We manufactured an artificial WR soil by mixing industrial sand with dimethyldichlorosilane (DMDCS). Drying and wetting retention curves were found for treated and untreated material using pressure plates.
- Shear strengths of both materials were examined under a range of suctions and normal stresses
- WR soil retention curves resembled hydrophilic counterparts but were displaced to higher suctions
- **No significant difference was found** between the two materials' behaviour in shear. **We believe this to be false**.

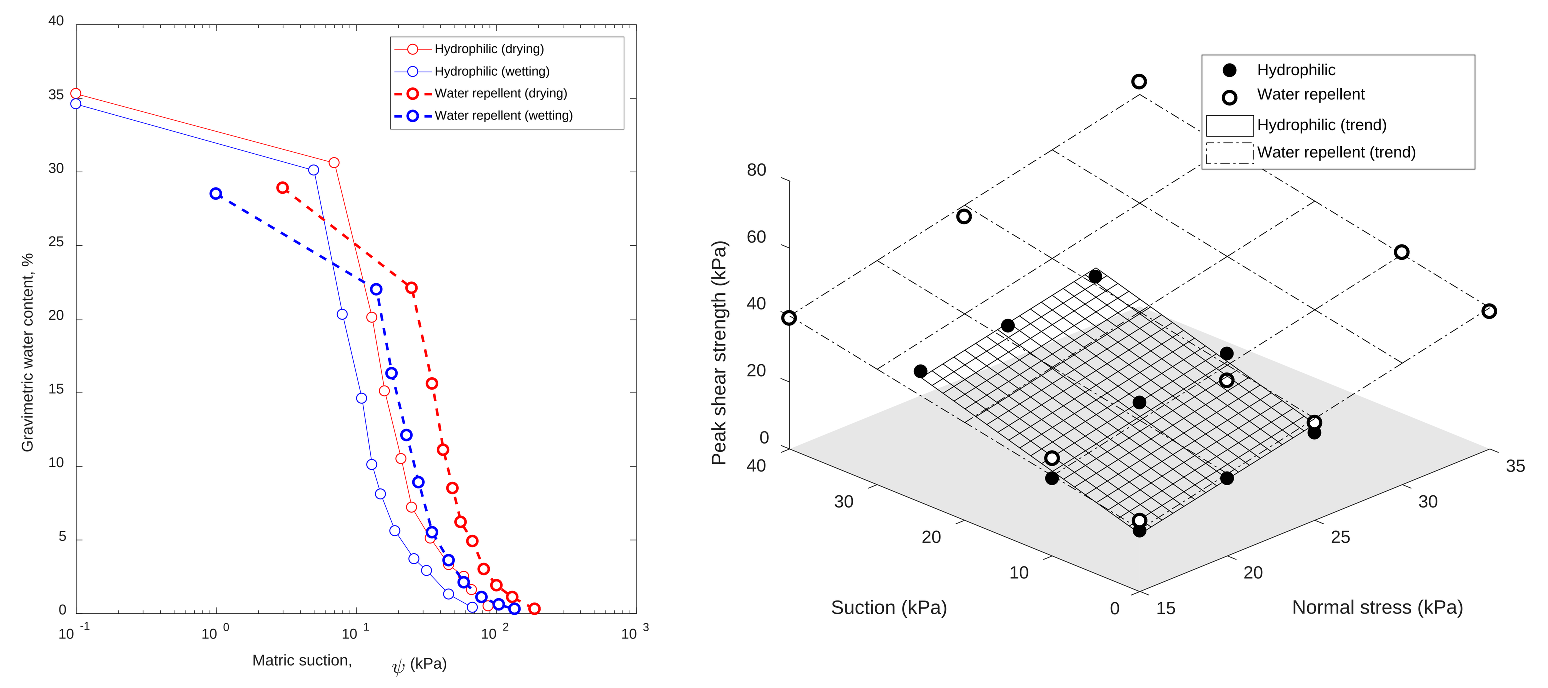

Figure 2. Water retention curves (left) and unsaturated shear strengths (right) for treated and untreated granular soil

Conclusions and new research

Axis translation techniques used in the preliminary study masked repellency's effects by forcing water menisci to adopt concave shapes. This new PhD project will examine the fundamental behaviour of WR soils and how they can be used in the field:

- Understanding the formation and evolution of water menisci between WR particles
- Understanding the mechanical and chemical properties of DMDCS-treated sand and how these are affected by testing technique
- Examining material repellency longevity *in situ* and environmental consequences of DMDCS treatment

A fascinating material

WR soils represent a broad range of geotechnical and agricultural challenges and opportunities. However, a myriad of questions surrounding their use exist which cannot be tackled by one group alone.

As part of our project, we will offer laboratories and groups samples of our WR soil for free. Please contact us by scanning the QR code to the right or via the group email addresses given above.

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